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(54) PRESSURE TRANSDUCER

(71) We, E M I LIMITED, a British company of Blyth Road, Hayes, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to pressure transducers.

Transducers may be used for medical pressure measurements on a patient, e.g. when blood pressure is measured via a catheter entering the blood stream. Some transducers comprise transducer elements which are, or parts of which are, fragile and so there is also the risk of broken parts of a transducer element entering the blood stream.

It is an object of the invention to provide a pressure transducer in which such risks are reduced.

According to the invention there is provided a pressure transducer including a housing having a metal diaphragm forming part of a wall of the housing and a transducer element within the housing, the element comprising a body of semiconductor material in the form of a rigid ring integral with and surrounding a flexible portion, the ring being bonded to the housing and the said flexible portion or an integral extension thereof being bonded to the metal diaphragm.

The transducer element may be secured by anodic bonding. The element may be secured at all points of contact with the metal diaphragm.

Embodiments of the invention will now be described, by way of example only, with reference to the drawings filed with the Provisional Specification in which:-

Figure 1 shows in cross-section a transducer having a transducing element enclosed in a housing and

Figures 2, 3 and *4*, show alternative constructions for housing a transducing element.

A transducer element 1 is formed from a single piece of semiconductor material as an integral construction of a stiff mounting ring 10, a deflectable portion 11 and a force transmitting member 12. Suitable forms of, and methods for making, this element are well-known in the art. For example the element may be cut from a body of silicon material previously planar processed to produce a piezo-resistor pattern, and selectively etched to produce the deflectable portion.

The housing 2 has an end-wall 21 which is rigid but has a portion of reduced thickness 2 flexible to form a pressure transmitting diaphragm. The housing 2 may be of welded construction in cylindrical or other suitable form and provided with electrical connections (not shown) for the transducer element. The wall 21 is preferably of a low-corrosion material, such as titanium or stainless or nickel-steel and the diaphragm 22 may be formed by electrochemical machining. Altenratively a thin sheet of material may be welded across a hole in wall 21. Other considerations being equal a material of similar coefficient of expansion to the element 1 is preferred.

The element 1 is attached to the diaphragm at all points where contact occurs. Thus in Figure 1 the force transmitting member 12 is bonded to the inside face of diaphragm 22 and the ring 10 is bonded to the wall 21. Anodic bonding is suitable although other methods may be used provided a bond at each point of contact and over all the area of contact at such a point is obtained.

Other forms of construction for the transducer are shown at Figures 2, 3 and 4. Similar items are identified by the same references as used in Figure 1.

In Figure 2 the element 1 is enclosed inside an electrical component encapsula-

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tion 13 such as the "dual in-line flat-pack". The encapsulation can include an amplifier or other processor 14 for the signals from the element 1. Suitable internal connections such as 15 can be provided to the terminals 16. Figure 2 also shows a form of welded-in construction for a separate diaphragm 221.

Figure 3 shows a transducer arranged to measure absolute pressure rather than the gauge pressure measured by the transducers of Figures 1 and 2. A silicon disc 17 is attached by a glass bond 18 to the element 1 on the face opposite that attached to the diaphragm 222. A chamber 19 is formed in this way and is evacuated and then sealed. The displacement of portion 11 of the element 1 is no longer resisted by atmospheric pressure on the rear face so an absolute measurement is obtained. The diaphragm 222 is formed by machining into the inner face of wall 21.

In Figure 4 the diaphragm is of similar form to that in Figure 3 but the element 1 has a flat face 111 on deflectable area 11 which is wholly in contact with and bonded to diaphragm 222. Mounting ring 101 is also attached to diaphragm 222.

In operation of the transducers described above (which are particularly suitable for medical measurements), even if the transducer element should fracture, e.g. due to transient over pressure or mechanical shock, the diaphragm will contain the transducer element parts and prevent these entering a patient's blood stream. Furthermore the metal diaphragm tends to prevent potential energising the element from reaching the patient. Electrical protection in the form of an earthing connection to the diaphragm may be provided. The provision of a metal diaphragm with the element bonded to it at all points of contact provides adequate transmission of pressure applied as indicated by arrow P, for example via a catheter for in-heart blood pressure measurements. The construction of the element 1 with a surrounding mounting ring can reduce the effect of any differential thermal expansion of the diaphragm and element while retaining the good frequency response and low hysteresis associated with semiconductor transducing elements. The transducer may be combined with a catheter for transmitting blood pressure to the transducer.

WHAT WE CLAIM IS:-

1. A pressure transducer including a housing having a metal diaphragm forming part of a wall of the housing and a transducer element within the housing, the element comprising a body of semiconductor material in the form of a rigid ring integral with and surrounding a flexible portion, the ring being bonded to the housing and the said flexible portion or an integral extension thereof being bonded to the metal diaphragm.

2. A transducer according to claim 1, wherein the metal diaphragm is of titanium, stainless-steel or nickel-steel.

3. A transducer according to claim 1 or 2 wherein the metal diaphragm is formed integrally with a housing wall.

4. A transducer according to claim 1 or 2 wherein the metal diaphragm is joined to the housing and covers an aperture in the housing.

5. A transducer according to any preceding claim, wherein the said ring, and the said flexible portion or its integral extension, are bonded to the metal diaphragm at all points of contact therewith.

6. A transducer according to any preceding claim, wherein the transducer element is bonded to the metal diaphragm by anodic bonding.

7. A transducer according to any preceding claim, wherein the said flexible portion comprises a face wholly in contact with and bonded to the metal diaphragm.

8. A transducer according to any one of claims 1 to 6, wherein the said flexible portion is spaced from the metal diaphragm and has the said integral extension which is bonded to the metal diaphragm for transmitting force from the metal diaphragm to the flexible portion.

9. A transducer according to claim 7 or 8 wherein the face of the said flexible portion remote from the metal diaphragm defines a wall portion of an evacuated chamber.

10. A pressure transducer substantially as hereinbefore described with reference to Figure 1, 2, 3 or 4 of the drawing accompanying the provisional specification.

11. A transducer according to any preceding claim in combination with a catheter for transmitting blood pressure to the transducer.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

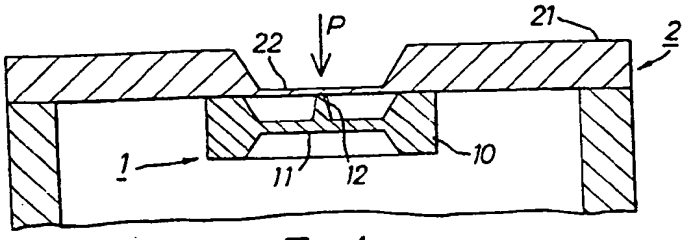

FIG.1

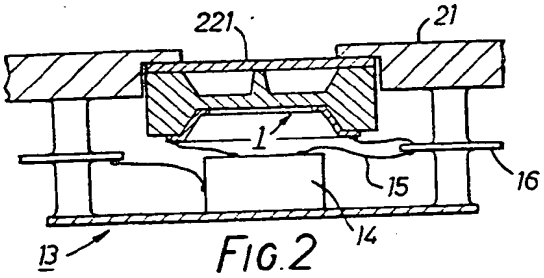

FIG.2

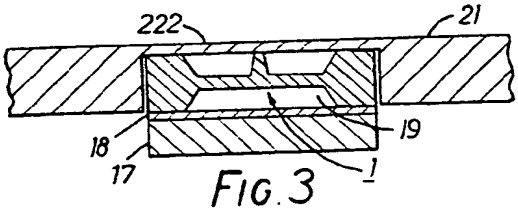

FIG.3

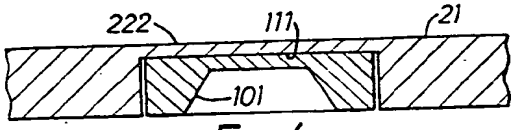

FIG.4